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Paleoecology and sedimentary environment of the Late Devonian coral biostrome from the Central Devonian Field, Russia

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ABSTRACT

The upper Frasnian coral biostrome, well-exposed in the Russkiy Brod quarry, Central Devonian Field, Russia, has been studied in detail with respect to paleoecology and sedimentary environment. The biostrome, formed by auloporid tabulates and solitary and colonial rugose corals, originated in an offshore environment characterized by calmer periods with slow or halted sedimentation, and more energetic periods when sedimentation rate increased. The episodic, higher sediment influx and stronger hydrodynamic regime are not only well-expressed in the microfacies, but also in the variability of colony integration of the rugose corals observed even within single coralla. Distinct development of constrictions, rejuvenescences and deflection of growth directions in rugose corallites may also indicate unstable sedimentary conditions. The latter features, however, may have, in part, also resulted from *syn vivo* biotic interaction with the associated auloporids. Both the facies and paleontological observations suggest that the biostrome originated by the colonization of deposited bioclasts by pioneering auloporids, creating the framework for settlement of later generations of auloporids and rugose corals. Apart from abundant auloporids representing a single species and associated rugose corals, the other encrusters are not numerous and poorly diversified, represented by dominating foraminifers, followed by single species of productid brachiopods, stromatoporoids, microconchids and cornulitids. The coral-associated macrobenthos has similarly a low diversity, being represented by single species of spiriferid and rhynchonellid brachiopods, and gastropods. Being developed in an offshore carbonate sedimentary system devoid of any organic-rich deposits, and characterized by extremely low abundance and diversity of suspension-feeding organisms, the biostrome is considered to have originated in a low productivity, oligotrophic environment strictly dominated by heterozoan coral communities. Its development in a well-oxygenated, oligotrophic environment during the time when organic-rich, black Kellwasser facies developed elsewhere, additionally attests for multi-causal scenarios for the Frasnian–Famennian event, during which other factors were responsible in different paleogeographic and facies settings.

1. Introduction

The Late Devonian was a time of great reorganization of the biosphere. In particular, this time interval is best known for several anoxic events in marine environments and two major extinction events in the history of life. The first extinction took place in the latest Frasnian, close to the Frasnian–Famennian (F–F) boundary (e.g., McGhee, 1996; Hallam and Wignall, 1997; Racki, 2005), and the second, well-known as the Hangenberg event, took place close to the Devonian–Carboniferous (D–C) boundary (e.g., Walliser, 1996; Kaiser et al., 2006, 2011; Marynowski et al., 2012; Myrow et al., 2014). Although the Hangenberg event is considered to have been even more severe for existing organisms than the F–F biotic crisis, the latter one had a strong impact on ecological systems, especially the reef ecosystems. It is known from the geological record that globally, the last metazoan reefs vanished by the end of the Frasnian.

The causes of the extinction of late Frasnian metazoan reefs, which was one of the largest in the Phanerozoic (e.g., Wood, 2000; Copper, 2002; Morrow et al., 2011), are still a matter of debate. Some authors (e.g., Bond and Wignall, 2008; Bond et al., 2013) link the F–F extinction event to a widespread transgression delivering anoxic waters from deep basins onto the shallow shelves. Also, eutrophication triggered by nutrient input to shallow water

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environments (related to upwelling or continental run-off, as well as volcanic and hydrothermal activity) was considered as a factor leading to the onset of anoxic conditions (e.g., Murphy et al., 2000; Joachimski et al., 2001; Racki et al., 2002; Riquier et al., 2005, 2006; Pujol et al., 2006). Others link the event to profound atmospheric CO_2 drawdown leading to global, glacially driven cooling and associated regression exposing large areas of shelves (e.g., Copper, 1986, 2002; Joachimski and Buggisch, 1993, 2002; Chen and Tucker, 2003, 2004). However, whatever the ultimate and proximate causes of the demise of metazoan reefs and organic build-ups in the latest Frasnian, the effect must have been severe, as following the F–F crisis they did not recover, but were replaced by microbial build-ups in the post-extinction early Famennian environments (e.g., Becker et al., 1991; Wood, 2000; Copper, 2002; Whalen et al., 2002; Shen et al., 2008). Very rare and non-reef-building colonial rugose corals appeared, but not before the mid-Famennian (Oliver and Pedder, 1994; Poty, 1999; Berkowski, 2001, 2002; Copper, 2002; Liao, 2002), either as Lazarus or new taxa (Berkowski, 2001). Thus, any data concerning the last, late Frasnian pre-extinction metazoan build-ups is important in order to understand their paleoecology and paleoenvironmental conditions before their final demise.

In the present paper we focused on a coral biostrome well-exposed in the Russkiy Brod quarry, located in the Central Devonian Field, Russia. Its good accessibility allowed for detailed analysis similar to that designed by modern marine ecologists working on benthic communities. The main aims of the study are to 1) characterize the coral and associated macrobenthos composition, 2) analyze the associated encrusters present in the biostrome, 3) reconstruct the biotic interactions occurring within the biostrome, and 4) draw a coherent picture of the origin, paleoecology, and sedimentary environment of the coral biostrome. Being developed during the latest Frasnian, this coral biostrome is one of the last of its kind before the F–F biotic crisis.

2. Geological setting

The Central Devonian Field (CDF), situated in the central-western part of the East European Platform (Fig. 1A–B), is a classic and large area where Devonian deposits are well-exposed and undisturbed by fold tectonics. The CDF stretches through the Moscow Syneclise and the Voronezh Anteclise, south of Moscow (Fig. 1B).

During the Late Devonian, the area of the CDF was occupied by a shallow-water, epicratonic marine basin linked by narrow pathways with the Paleotethys and opening into the Uralian Ocean to the east (Golonka et al., 1994). Basin evolution was controlled by eustatic sea-level changes and local tectonics (Alekseev et al., 1996). In general, the basin was bounded by the highland of the Baltic Shield to the north, by lowlands to the west, and by land of the Ukrainian Shield to the south. The area was located in the subtropical climatic zone, characterized by a hot, dry climate under which the lagoons and restricted bays known in the western part of the CDF developed in hypersaline conditions (Rodionova et al., 1995; Tikhomirov, 1995).

The area studied here, located in the central part of the Voronezh Anteclise (Fig. 1B), corresponded to the near-shore southwestern part of the Late Devonian basin. The F–F boundary beds, comprising two regional stages (Livny and Zadonsk in ascending order), are represented by shallow-water carbonate and clayey sedimentary rocks. The F–F

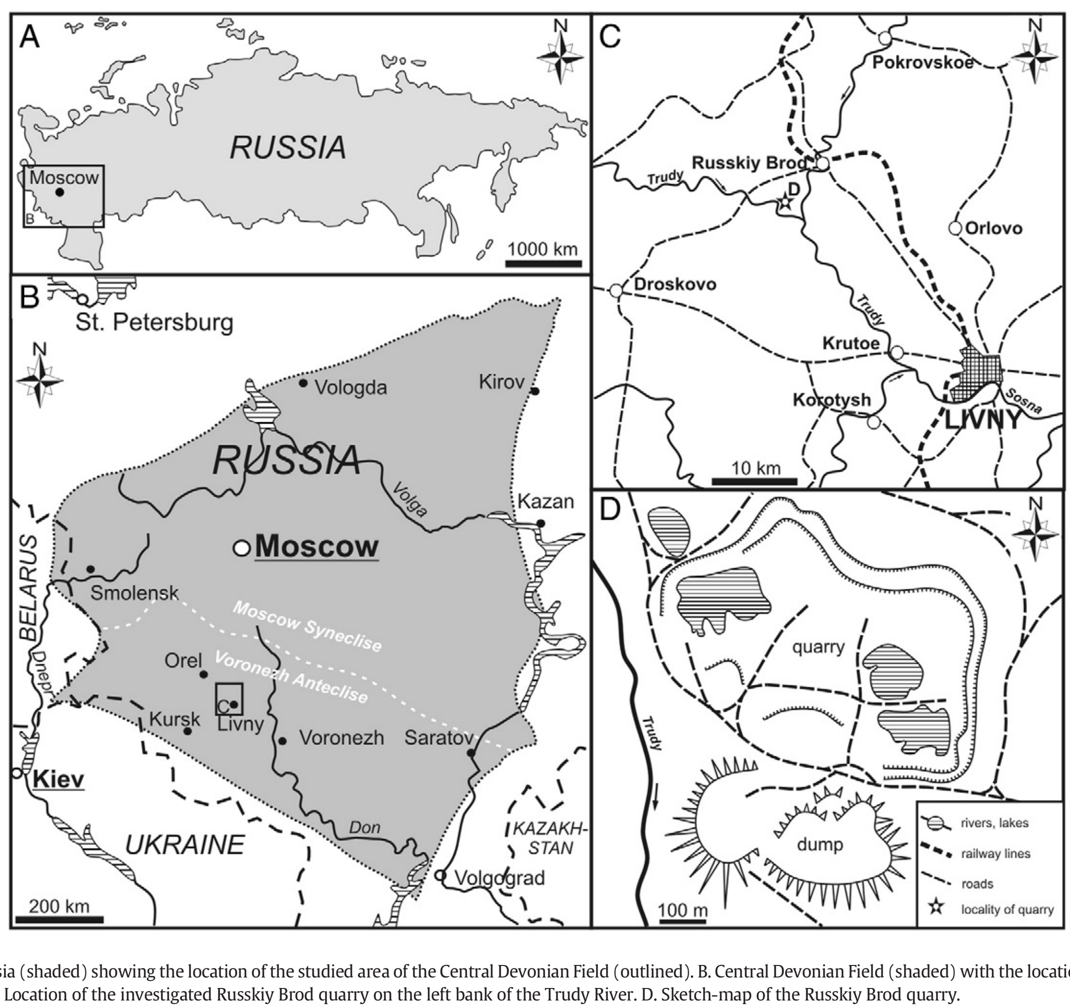

Fig. 1. A. Map of Russia (shaded) showing the location of the studied area of the Central Devonian Field (outlined). B. Central Devonian Field (shaded) with the location of the investigated quarry (outlined). C. Location of the investigated Russkiy Brod quarry on the left bank of the Trudy River. D. Sketch-map of the Russkiy Brod quarry.
Adapted from Zatoń et al. (2014).